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(19)

(54) BEARINGS

(71) We, LABORATOIRE SUISSE DE RECHERCHES HORLOGERES, a Company organised under the laws of Switzerland, of Rue A.-L Brequet 2, 2000 Neuchatel 7, Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

This invention relates to bearings of the type comprising elements which roll between relatively rotatable races. Examples of such bearings are ball bearings, cylindrical and taper roller bearings and needle roller bearings. For convenience, all bearings of the said type will be referred to herein generically as rolling bearings.

The invention is concerned with precision rolling bearings conforming to AFBMA standards up to ABEC 9 for applications up to and including extreme environmental conditions; in particular for applications in outer space, in high temperature nuclear reactors and for the bearings of rotating X-ray anodes and anti-cathodes, under continuous or intermittent operation up to the highest rotation rates in ultra-high vacuum or in an inert atmosphere at temperatures up to 180°C and above.

Rolling bearings which are to be used for such applications cannot be lubricated normally, since even the most resistant liquid lubricants evaporate at temperatures above 180°C and/or in a high vacuum. The coefficient of friction of steel against steel without lubricant is very high, and at a temperature of 320°C in high vacuum (10^{-4} m bar) or in helium is up to 20 times greater than when lubricated.

Welding between the race material and the rolling elements of the bearings leads to excessive wear and a very short life. As a result of the wear the bearing characteristics are continually changing. For the temperature range up to 450°C and in high vacuum, ball bearings with titanium carbide coated races have been used (Schweizer Archiv fur angewandte Wissenschaft und Technik, Vol *33* (1967) pages 157-166 and Vol *36* (1970), pages 189-193, and Proceedings of the First European Space Tribology Symposium, Frascati, ESA SP III, Italy, 9-11 April 1975, page 281-291). Titanium carbide has a very low coefficient of friction against steel and also serves in such applications as a diffusion barrier against the steel balls. The disadvantage of that protective coating, which is prepared by a deposition from the gas phase, is the high deposition temperature (800-1200°C). Rolling bearing steels, such as steels conforming to the standards DIN 100 Cr 6 or AISI 440C, shows such a large deformation at these temperatures that bearings conforming to AFBMA standards up to ABEC 9 cannot be produced.

The invention aims to provide a new type of precision rolling bearing for application in extreme environments, conforming to AFBMA standards up to ABEC 9.

According to the present invention, there is provided a precision rolling bearing the rolling elements of which are made of cemented carbide and coated with a material, acting as a diffusion barrier, comprising one or any combination of a carbide, nitride, carbonitride, boride, silicide or oxide of one or more elements in groups III to VI of the periodic table, or mixtures or mixed crystals thereof.

Rolling bearings according to this invention also utilise the good friction properties of titanium carbide or other suitable hard materials, against steel, and their low solubility in each other, in order that the surfaces of the friction partners have the required physical-chemical properties.

The cemented carbide rolling elements can be coated at high temperatures without damage or deformation. Manufacturers of precision rolling bearings can finish these coated rolling elements to the tolerance required by the appropriate standard, such as an AFBMA standard.

In this way it is also possible to give precision bearings the required protection for applications under extreme conditions. In addition, the cemented carbide rolling elements provide the bearings with a 10-20% increased stiffness.

Preferably the bearing races are made of bearing steel, a high temperature resistant alloy, a corrosion resistant alloy cemented carbide, cermet or ceramics.

The cages may be made from a metal such as steel commonly used for this purpose which may have a dry lubricant coating, or from a plastics material which may or may not have self-lubricating inclusions, additions or coatings.

Allowing for additional finishing and according to the requirements of the bearing standard; the hard metal rolling elements are ground to the required accuracy and tolerance. They are then coated with a hard material by chemical vapour deposition or by another suitable process. This can be done according to the process described in Swiss Patent No. 455,856 for precision parts.

The rolling elements are then finished to the required accuracy and the bearing is assembled with the cages and races.

Series-produced, demountable races conforming to the required standard can be used.

The invention is illustrated by the following examples:

Example 1

The lifetime of rolling bearings for a helium-cooled nuclear reactor should be increased in order to increase the time between services.

Ball bearings were made with cemented carbide balls coated with a 6 μm thick diffusion barrier of titanium carbide by the chemical vapour deposition process as described in U.S. patent No. 3642522, with races of rolling bearing steel conforming to the standard DIN 100 Cr 6 and with molybdenum disulphide coated steel cages. The bearings had a lifetime 25 times longer than that of normal bearings using steel balls when used in pure helium at 320°C and at 100 rev/min.

Example 2

Bearings of high speed rotating X-ray anodes (anti-cathodes) are subjected during their operation to very intense thermal radiation. The use of conventional bearings not only necessitates very frequent servicing but also incurs the risk of breakdown of the X-ray unit at a critical moment.

In order to improve the lifetime of high speed rotating X-ray anodes and anticathodes ball bearings can be used having cemented carbide balls coated by a suitable process, e.g. as described in U.S. patent No. 3642522, with a diffusion barrier of titanium carbide of 6 μm thickness, with races of rolling bearing steel conforming to DIN 100 Cr 6 and with molybdenum disulphide coated bronze cages. Even with conventional lubricants the bearing has the advantage of outstanding reliability due to the low coefficient of friction between titanium carbide and steel.

Example 3

Bearings for outer-space applications must be protected against welding. In addition, due to the limited available supply of energy they should have a very low starting moment.

Ball bearings with titanium carbide coated cemented carbide balls, races of stainless steel conforming to the standard AISI 440C and polyimide cages have the required physical-chemical properties for outerspace applications, such as low friction coefficient (one eighth of that for steel against steel) and low mutual solubility of steel and titanium carbide which hinders the cold-welding of the rolling friction partners.

In modifications of these Examples, other forms of rolling elements such as rollers may be used instead of balls.

WHAT WE CLAIM IS:—

1. A precision rolling bearing the rolling elements of which are made of cemented carbide and coated with a material, acting as a diffusion barrier, comprising one or any combination of a carbide, nitride, carbonitride, boride, silicide or oxide of one or more elements in groups III to VI of the periodic table, or mixtures or mixed crystals thereof.

2. A precision rolling bearing according to Claim 1, in which the bearing races are made of bearing steel, a high temperature resistant alloy, a corrosion resistant alloy, cemented carbide, cermet or ceramics.

3. A precision rolling bearing according to Claim 1 or Claim 2, having cages for rolling elements made of a metallic or non-metallic material with or without self-lubricating inclusions, additions or coatings.

4. A precision rolling bearing according to Claim 3 the cage of which is made of a plastics material with or without self-lubricating inclusions, additions or coatings.

5. A precision rolling bearing substantially as herein described in any of the Examples.

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